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(54) **POWER TAKE-OFF CLUTCH ASSEMBLY**

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F16H 37/02 (2006.01)
B60K 17/28 (2006.01)

(52) **U.S. Cl.**
CPC ***B60K 17/28*** (2013.01); *B60Y 2300/73* (2013.01); *B60Y 2400/422* (2013.01); *B60Y 2400/423* (2013.01)

(58) **Field of Classification Search**
CPC B60Y 2300/73; B60Y 2400/422; B60K 17/28
USPC 74/11, 15.82, 15.84
See application file for complete search history.

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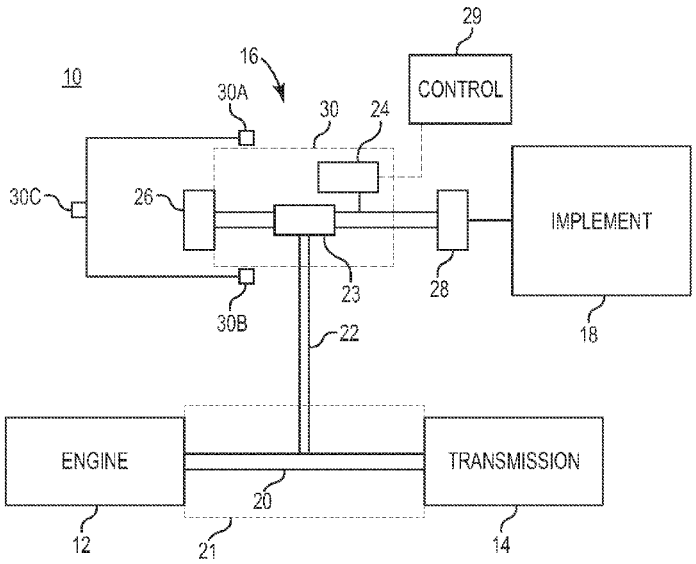
(57) **ABSTRACT**

A clutch assembly is provided for engaging a PTO assembly with a primary drive shaft of a vehicle engine. The clutch assembly includes a synchronizing clutch for rotating an output member and a primary clutch positionable to rotationally connect the output member to the primary drive shaft.

24 Claims, 6 Drawing Sheets



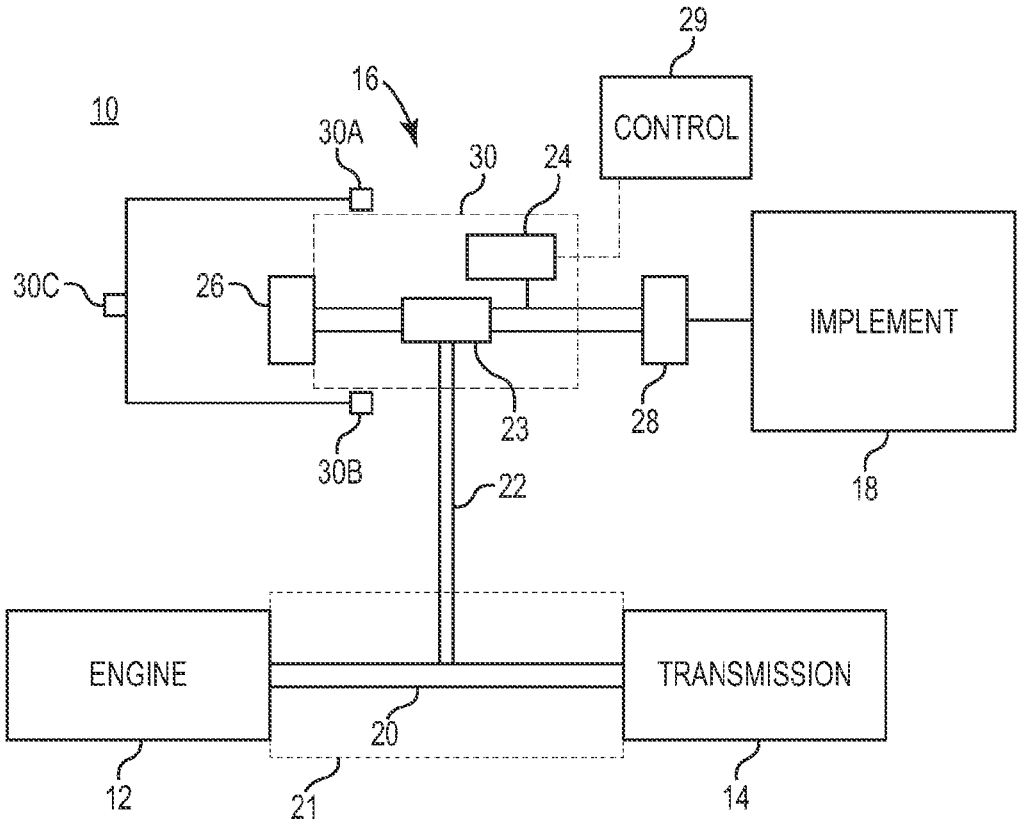

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Fig. 1

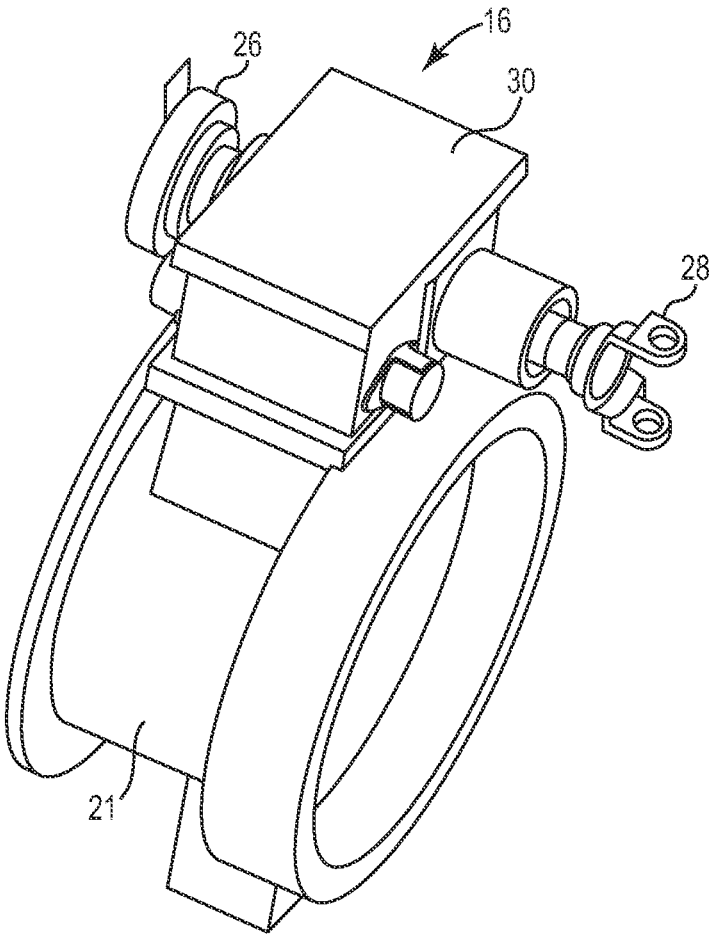

Fig. 2

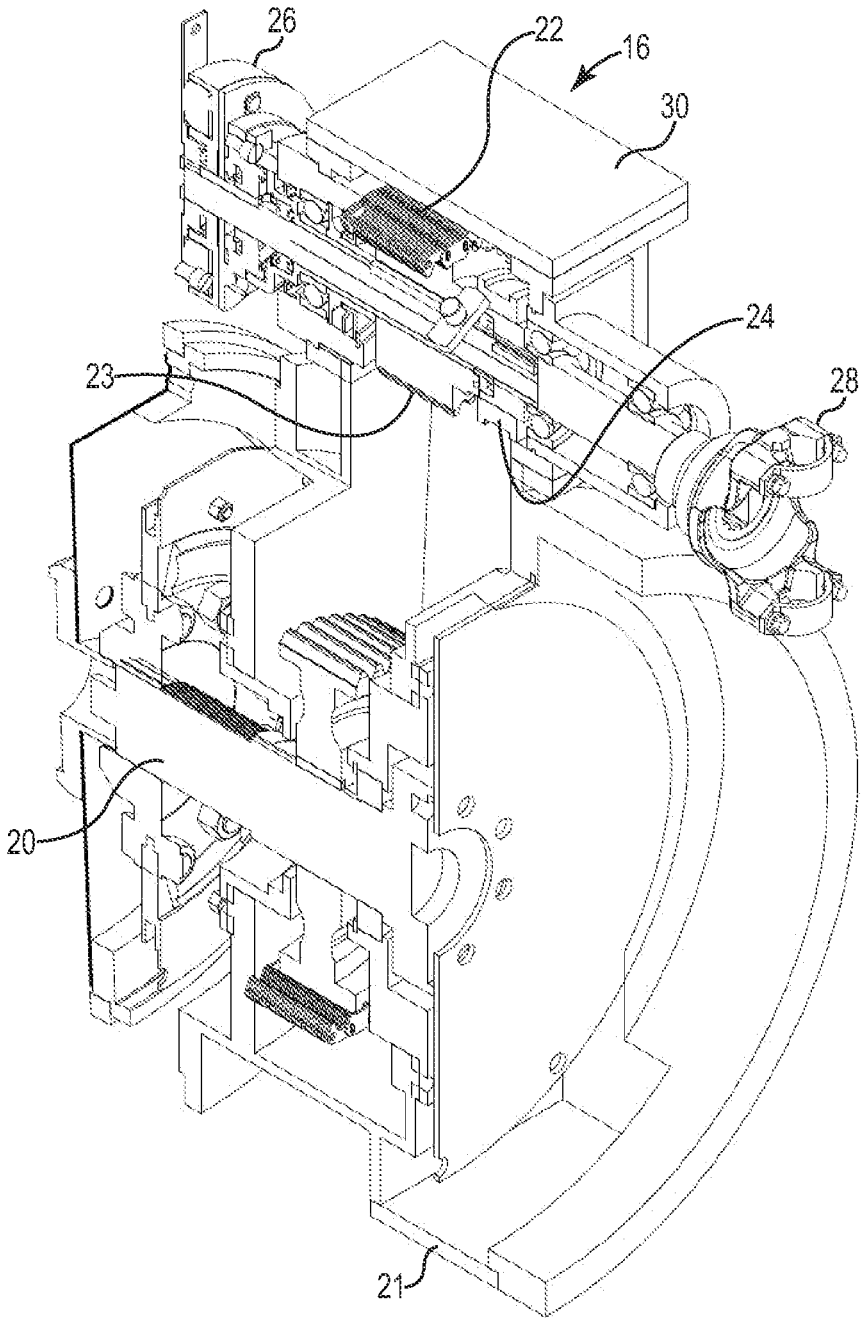

Fig. 3

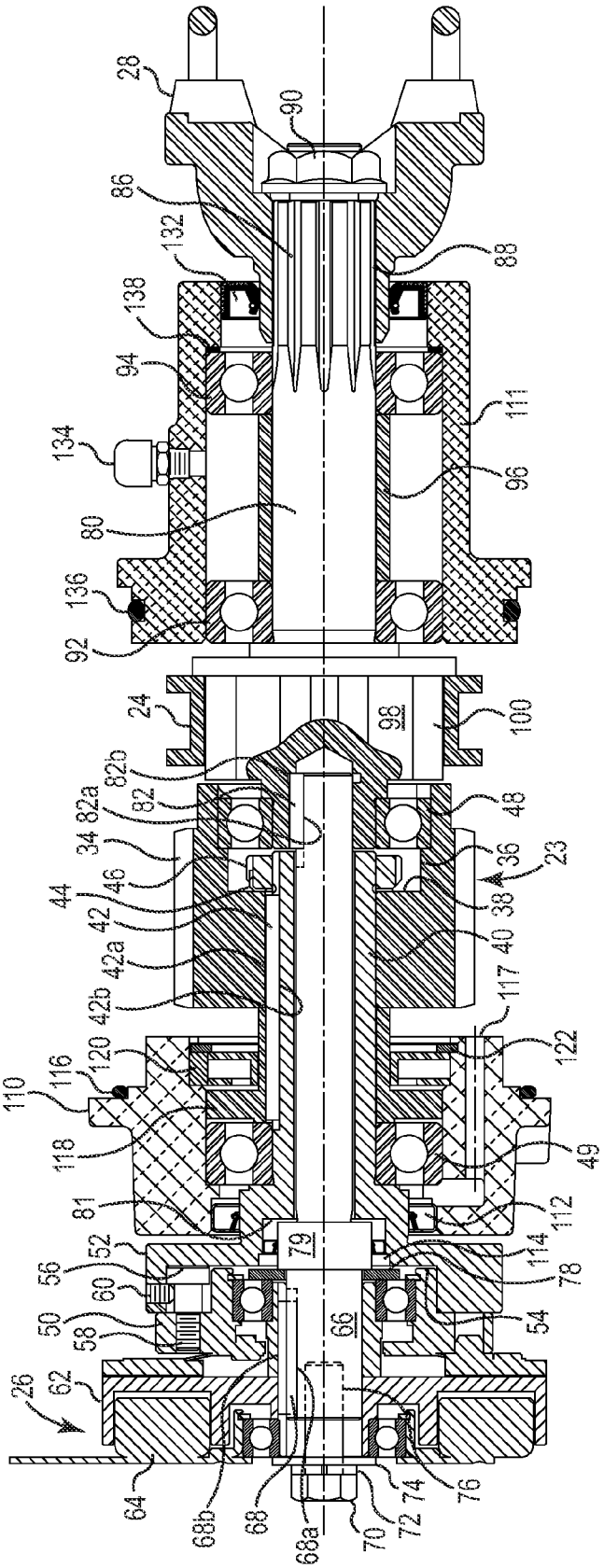
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Fig. 4

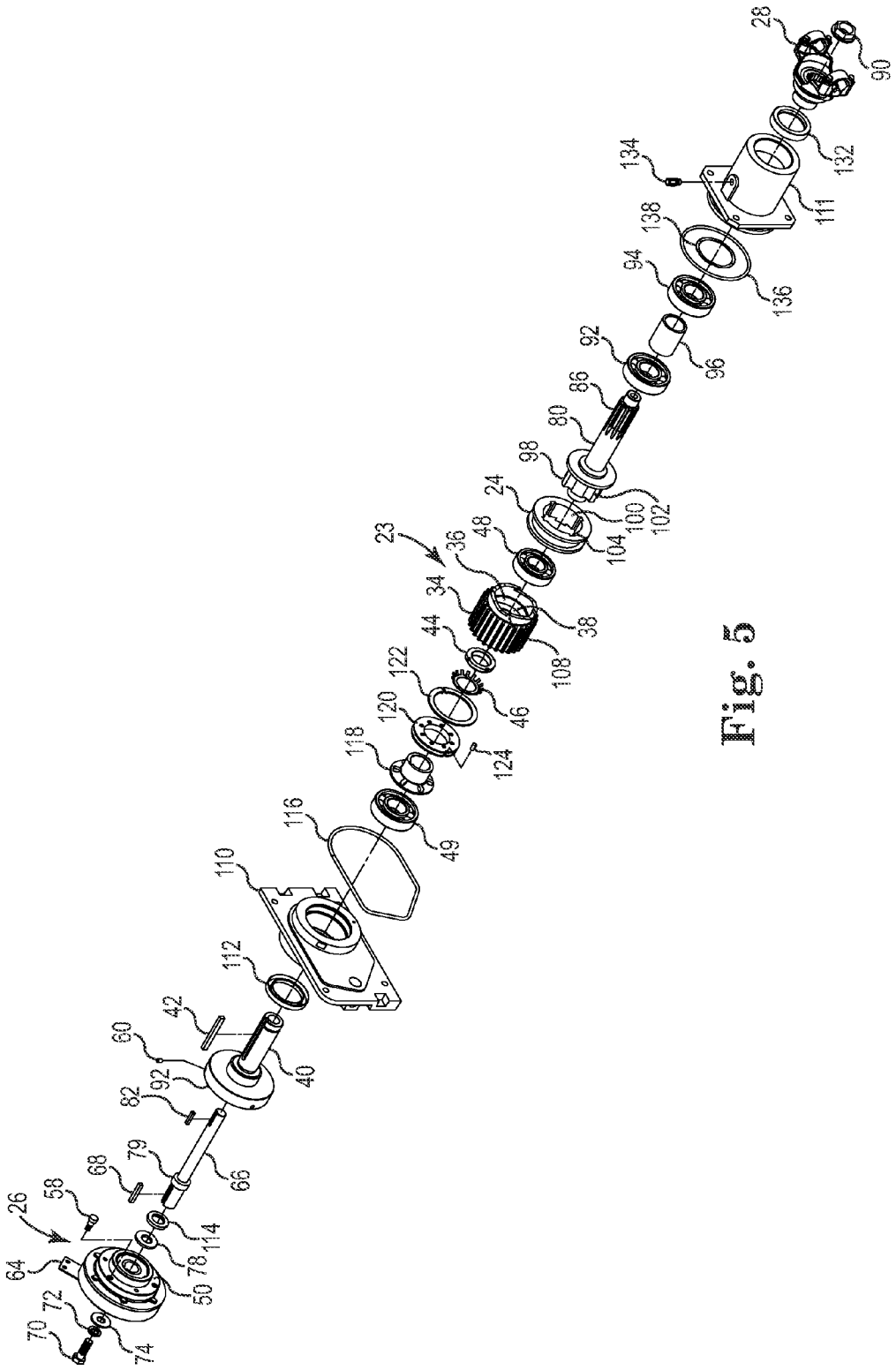
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Fig. 5

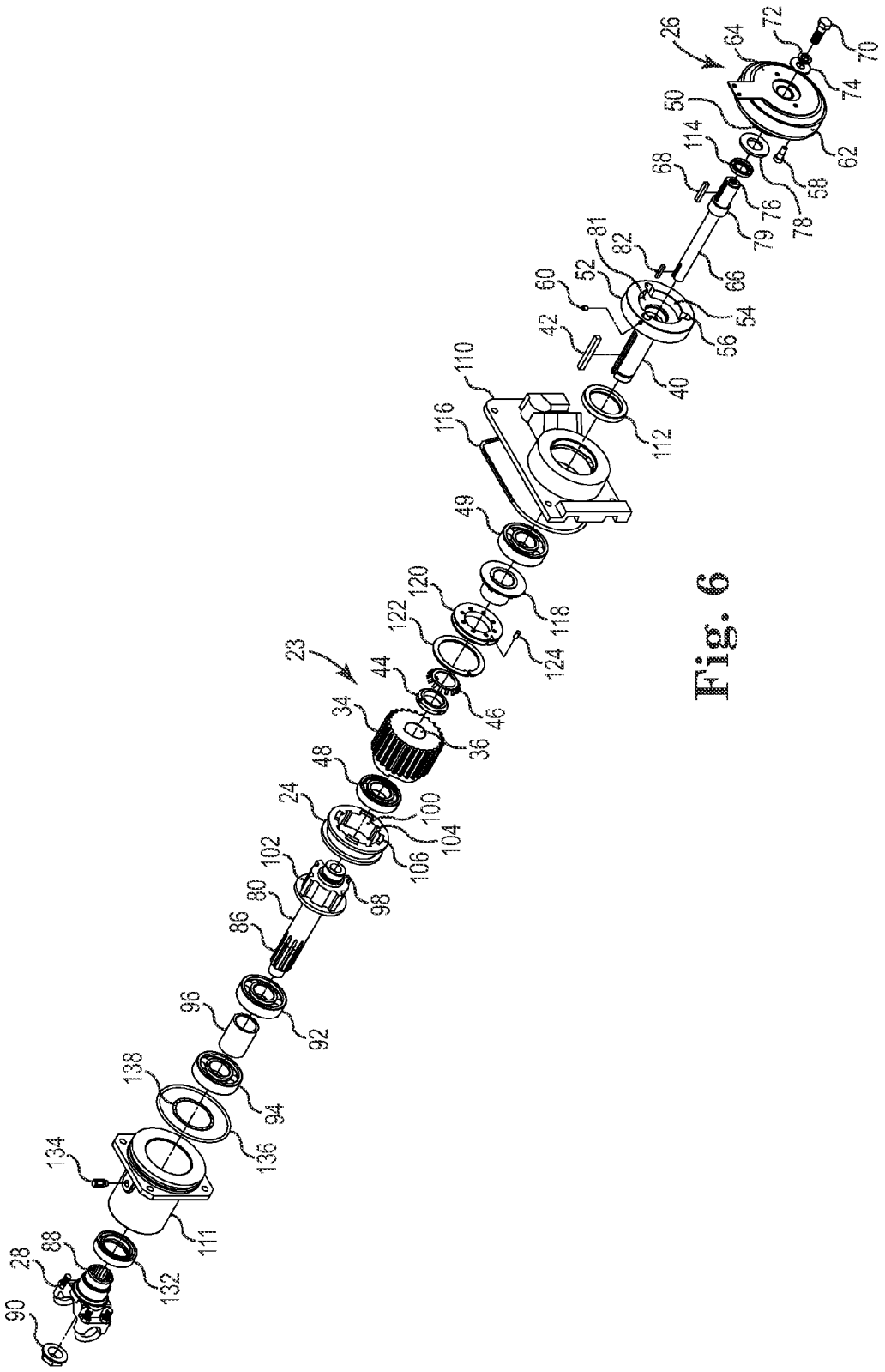
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Fig. 6

POWER TAKE-OFF CLUTCH ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119(e) to U.S. Provisional Patent Application Ser. No. 61/537,158 filed on Sep. 21, 2011, and incorporated herein by reference.

BACKGROUND

Vehicles such as trucks and tractors can employ a power take-off ("PTO") assembly used to power an implement such as an auxiliary attachment or separate machine. For example, a fire truck may employ a PTO assembly to power a water pump. In some instances, the PTO assembly allows the implement to draw energy or power from the vehicle's engine by employing a clutch assembly to connect/disconnect the PTO assembly with the vehicle's engine. Current clutch assemblies include split-shaft PTO assemblies, chassis transmission-mounted PTO assemblies and sandwich PTO assemblies. In a split-shaft PTO assembly, the main drive shaft of the vehicle is required to be disengaged from a rear differential in order for the PTO assembly to be engaged, which prevents a pump driven by the PTO from operating while the vehicle is in motion. In a chassis transmission-mounted PTO assembly, the PTO assembly draws power directly from the transmission, which can limit a size of pump that can be used with such a PTO assembly. Sandwich PTO assemblies can be positioned between a main engine and transmission to conserve space. However, the clutch employed is limited by size and expense in order to provide sufficient power to operate the implement.

SUMMARY

A clutch assembly is provided for engaging a PTO assembly with a primary drive shaft of a vehicle engine. The clutch assembly includes a synchronizing clutch for rotating an output member to a speed that is synchronized with the drive shaft. Once rotation of the output member and drive shaft are synchronized, a primary clutch is positionable to rotationally connect the output member to the primary drive shaft such that torque passes directly from the drive shaft, through the primary clutch and to the output member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of elements of a vehicle employing a power take-off assembly.

FIG. **2** is an isometric view of an exemplary power take-off assembly and drive shaft housing.

FIG. **3** is a sectional view of the exemplary power take-off assembly and drive shaft housing of FIG. **2**.

FIG. **4** is a sectional view of a power take-off clutch assembly.

FIG. **5** is an exploded isometric view of the power take-off clutch assembly illustrated in FIG. **4**.

FIG. **6** is an exploded isometric view of the power take-off clutch assembly illustrated in FIG. **4** from an alternate perspective to that illustrated in FIG. **5**.

DETAILED DESCRIPTION

FIG. **1** is a schematic view of a vehicle **10** that includes an engine **12**, a transmission **14** and a power take-off (PTO) assembly **16** configured to selectively drive an implement **18**.

Engine **12** rotationally drives a primary drive member **20** (e.g., a drive shaft) contained within a suitable drive shaft housing **21** in order to supply power to transmission **14**, which, in one embodiment, is used to drive wheels of the vehicle **10**. FIGS. **2** and **3** illustrate an isometric view and sectional view of an exemplary embodiment of the PTO assembly **16** and drive shaft housing **21**, respectively. PTO Assembly **16** is positioned between the engine **12** and transmission **14** (i.e., a sandwich PTO assembly) and is utilized to engage primary drive member **20** in order to drive the implement **18**. In particular, the PTO assembly **16** is directly coupled to drive member **20** through a suitable connector **22** such as a belt, chain or gears. To selectively drive implement **18** with drive member **20**, PTO assembly **16** includes an input member **23** coupled with the connector **22**, an engagement mechanism operating as a primary clutch **24**, a synchronizing clutch **26** and an output member **28**.

Details of operation of elements in the PTO assembly **16** are provided below. In general, PTO assembly **16** operates to drive implement **18** through selective connection between the drive member **20** and output member **28**. The primary clutch **24** is utilized to selectively rotationally connect and disconnect the output member **28** with the primary drive member **20** through the input member **23**. In one embodiment, the primary clutch **24** rotationally connects the output member **28** and the primary drive member **20** while drive member **20** rotates. Engagement of the primary clutch **24** during operation of drive member **20** is known as a "hot shift". In this example, synchronizing clutch **26** is employed to provide rotation of output member **28** at a similar rotational speed to input member **23**. Upon engagement of the synchronizing clutch **26**, the output member **28** is rotationally "synchronized" with rotation of the input member **23**.

Once engaged, the primary clutch **24** is operated to engage input member **23** to directly couple the input member **23** with the output member **28** such that torque from drive shaft **20** is transferred from the input member **23**, through primary clutch **24** and to output member **28**. In one embodiment, engagement of the primary clutch **24** is initiated by a suitable control element **29** coupled with the primary clutch **24**. For example, control element **29** can include an actuator to selectively operate to engage primary clutch **24**. For example, control **29** can monitor time, compare relative speed of input member **23** and output member **28** (e.g., engage clutch **24** when output member is rotating at 90%, 95% or 100% of a speed of input member **23**) and/or monitor other elements of system **10** to determine when to initiate engagement of primary clutch **24**. Once primary clutch **24** is engaged, the implement **18** can draw power directly from the engine **12** and primary drive member **20**. After the output member **28** is coupled to receive torque directly from the primary drive member **20** through primary clutch **24**, the synchronizing clutch **26** can be disengaged. Based on this design, synchronizing clutch **26** need not include a sufficient amount of torque capacity necessary to drive the implement **18**. Instead, the synchronizing clutch **26** only is needed to rotate the output member **28** until the drive member **20** engages the output member **28** through primary clutch **24**.

In order to provide lubrication to elements of PTO assembly **16**, a sealed housing **30** is provided. Details of the sealed housing **30** are provided below. In general, however, housing **30** includes an inlet **30**A configured to receive a lubricant (e.g., oil) such that elements of the PTO assembly **16** receive sufficient lubrication. Furthermore, the housing **30** includes a collection outlet (or sump) **30**B to collect the lubricant after passing through the PTO assembly **16** and a pump **30**C to return the lubricant to the inlet **30**A of the housing **30**. In this

manner, sufficient lubrication is provided to the PTO assembly **16**. Moreover, PTO assembly **16** can include a passive oil collection system coupled with pump **30**C that can collect lubricant from both the outlet **30**B as well as lubricant collected proximate input member **23**. The collected lubricant can be pumped to an external lubricant cooler (not shown) and return to inlet **30**A during operation of engine **12**.

As illustrated in FIGS. **4-6**, PTO assembly **16** includes the input member **23**, herein embodied as a sprocket **34**, the primary clutch **24**, herein embodied as a shift collar, the synchronizing clutch **26**, herein embodied as an electromagnetic clutch and the output member **28**, herein embodied as a yoke. PTO assembly **16** is directly coupled to drive member **20** (FIG. **1**) through sprocket **34** coupled with connector **22** (FIG. **1**). In the embodiment illustrated, sprocket **34** is a toothed wheel, wherein connector **22** is a chain that engages teeth on the sprocket **34**. As such, sprocket **34** rotates together with drive member **20**.

Sprocket **34** further includes a central opening **36** defining a shoulder **38**. Sprocket **34** is also directly coupled to a hollow shaft **40** positioned within central opening **36** through a key **42** that directly rotationally couples the sprocket **34** and shaft **40**. Key **42** is herein embodied as a square key, although other means of coupling sprocket **34** with shaft **40** can also be used such as a splined connection, a pin connection, a press fit, a polygon profile shaft coupling with a corresponding bore, threads, welds, a brazed connection, a soldered connection and an adhesive connection. In particular, sprocket **34** includes an interior recess **42***a* and shaft **40** includes a corresponding recess **42***b* to engage key **42** such that sprocket **34** and shaft **40** rotate together. A bearing lock nut **44** and bearing nut washer **46** are used to secure shaft **40** within sprocket **34** against shoulder **38**. Additionally, a first ball bearing **48** and a second ball bearing **49** are provided to support rotation of shaft **40**.

Shaft **40** is in turn directly coupled to an exterior hub **50** of synchronizing clutch **26**. In the example shown, shaft **40** includes an enlarged end **52** defining an opening **54** that engages exterior hub **50** and extends along a length of shaft **40**. In particular, opening **54** defines a plurality of recesses **56** configured to receive corresponding screws **58** mounted directly to exterior hub **50**. Corresponding set screws **60** can be used to secure screws **58** within each of the recesses **56**. Based on connections discussed above, connector **22**, sprocket **34**, shaft **40** and exterior hub **50** each are configured to rotate when drive member **20** is operating. It will be appreciated that other methods of coupling shaft **40** with hub **50** can further be used.

Synchronizing clutch **26** further includes an interior hub **62** that, when clutch **26** is engaged, rotates with the exterior hub **50**. Both interior hub **50** and exterior hub **62** are coupled with a stator **64** such that both exterior hub **50** and interior hub **62** can rotate with respect to the stator **64**. Stator **64** can be mounted to a portion of vehicle **10** (FIG. **1**). As discussed above, synchronizing clutch **26** is an electromagnetic clutch. During operation, electricity is provided to induce a magnetic field that draws exterior hub **50** into contact with interior hub **62**. Due to friction, surfaces of the exterior hub **50** and interior hub **62** that contact each other will cause exterior hub **50** and interior hub **62** to rotate together. In an alternative embodiment, clutch **26** can be of a different configuration, for example a hydraulic clutch powered by lubricant entering through casing **30** (FIG. **1**). In this instance, hydraulic power would be used to bring surfaces of exterior hub **50** and interior hub **62** into contact with one another such that hub **50** and hub **62** rotate together. In yet a further embodiment, a pneumatic clutch could also be used such that pneumatic power brings surfaces of exterior hub **50** and interior hub **62** into contact with one another.

Interior hub **62** is rotationally coupled with an interior shaft **66** through a key **68**. Thus, when synchronizing clutch **26** is engaged, hub **62** and shaft **66** rotate with hub **50** and shaft **40**. To accommodate key **68**, shaft **66** includes a recess **68***a* whereas interior hub **62** includes a corresponding recess **68***b* configured to receive the key **68**. Key **68** is herein embodied as a square key, although other means of coupling hub **62** with shaft **66** can also be used such as a splined connection, a pin connection, a press fit, a polygon profile shaft coupling with a corresponding bore, threads, welds, a brazed connection, a soldered connection and an adhesive connection. In order to secure shaft **66** to interior hub **62**, a bolt **70** (or other suitable fastener) passes through a lock washer **72**, an exterior washer **74** and into a threaded opening **76** provided within shaft **66**. An interior washer **78** is provided between a shoulder **79** of the shaft **66** and the synchronizing clutch **26**.

Shaft **66** is sized to pass through opening **54** of shaft **40** and through opening **36** of sprocket **34** to engage an output shaft **80** positioned on an opposite side of sprocket **34** toward primary clutch **24**. As such, shaft **66** is coaxial with the shaft **40**, as is shaft **80**. A key **82** is provided to couple shaft **66** with output shaft **80**. In particular, shaft **66** includes a recess **82***a* whereas output shaft **80** includes a corresponding recess **82***b* that receives the key **82**. Key **82** is herein embodied as a square key, although other means of coupling shaft **66** with shaft **80** can also be used such as a splined connection, a pin connection, a press fit, a polygon profile shaft coupling with a corresponding bore threads, welds, a brazed connection, a soldered connection and an adhesive connection. Shaft **80** also includes a splined end **86** configured to engage interior splines **88** of yoke **28**. A nut **90** or other suitable fastener is provided to secure yoke **28** to shaft **80**.

Shaft **80** is supported by a pair of bearings **92** and **94** separated by a spacer **96**. On an opposite end of splined end **86**, shaft **80** includes a hub **98** configured to engage an interior surface **100** of primary clutch **24**. In particular, hub **98** includes a plurality of projections **102** that engage corresponding recesses **104** on interior surface **100** of primary clutch **24**. As such, shaft **80** is configured to rotate with primary clutch **24**. In order for shaft **80** to rotate with sprocket **34**, and thus with drive member **20** (FIG. **1**), a plurality of projections or dogs **106** are configured to engage corresponding projections or dogs **108** provided on sprocket **34**. When shaft **80** is rotating at a speed simultaneous to sprocket **34** upon engagement of synchronizing clutch **26**, primary clutch **24** can be positioned such that dogs **106** on primary clutch **24** engage dogs **108** on sprocket **34**. Upon engagement, shaft **80** and output member **28** will rotate with sprocket **34** and synchronizing clutch **26** can be disengaged. In one example embodiment, primary clutch **24** is coupled to an actuator mechanism such as an air solenoid valve that operates to position primary clutch **24** into engagement with sprocket **36**. Further still, the valve can be coupled with an operator switch that engages synchronizing clutch **26** and automatically shifts primary clutch **24** after output member **28** is synchronized with rotation of sprocket **34**.

Based on the above configuration, primary clutch **24** is positionable between a first position, wherein clutch **24** is spaced apart from the sprocket **34** (wherein sprocket **34** rotates independent of clutch **24**), and a second position, wherein the clutch **24** engages the sprocket **34** (wherein sprocket **34** and clutch **24** rotate together). In the first position, rotation of the output member **28** is based on engagement of the synchronizing clutch **26**. Thus, when primary drive shaft

20 is rotating and the synchronizing clutch 26 is engaged, output member 28 will rotate from torque transmitted through sprocket 34, shaft 40, synchronizing clutch 26 and shaft 66 while the primary clutch 24 is in the first position. When the primary clutch 24 is in the first position and the synchronizing clutch 26 is not engaged, output member 28 will not rotate. Conversely, when primary clutch 24 is in the second position, torque is directly transferred from sprocket 34, through clutch 24 and to output member 28.

In one embodiment and as discussed above, PTO assembly 16 can be encased, sealed and lubricated within a housing 30 (FIG. 1) to provide lubrication and/or cooling to elements within the PTO assembly 16. To seal elements of PTO assembly 16, a first housing portion 110 is positioned to surround shaft 40 and a second housing portion 111 is positioned to surround shaft 80. An external casing (shown in FIG. 2) extends between the first housing portion 110 and the second housing portion 111. A first oil seal 112 and a second oil seal 114 are provided to seal oil housing portion 110 against shaft 40 and shaft 66, respectively. The seals 112 and 114 prevent lubricant from exiting the PTO assembly 16 through housing portion 110. Furthermore, an o-ring 116 is provided to seal against oil housing portion 110 and the external casing.

Lubricant is provided to sprocket 34 through an entry port in the oil housing 30 (FIG. 1). An oil impeller 118 is rotatably coupled with shaft 40 through connection with key 42. Additionally, an oil concentrator 120 restrained within the housing 110 with a retaining ring 122. Lubricant from sprocket 34 can pass through oil concentrator 120 to impeller 118, where lubricant is pumped with fins on the impeller out of housing portion 110 to the pump 30C (FIG. 1). Lubricant that passes from the impeller 118 through bearing 49 is permitted to drain back within the housing 30 (for example to a housing sump 30B) through passageway 117 (FIG. 4). Optionally, a pin 124 is provided to orient the oil concentrator 120 and retaining ring 122. At an opposite end of the sealed casing, housing portion 111 surrounds the output shaft 80. The housing portion 111 is sealed with a seal 132 provided between yoke 28 and the housing portion 111. An oil breather 134 can be provided to provide relief to pressure within the housing 30. An o-ring 136 further provides a seal between the housing portion 111 and the casing. In addition, a wave spring 138 biases bearing 94 away from an interior of housing portion 111.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes can be made in form and detail without departing from the spirit and scope of the present invention.

What is claimed is:

1. A power take-off clutch assembly, comprising:
- a synchronizing clutch having a first hub and a second hub;
- an input member coupled to the first hub of the synchronizing clutch;
- an output member coupled to the second hub of the synchronizing clutch; and
- a primary clutch positionable between a first position and a second position with respect to the input member such that, in the first position, the output member rotates based on torque transmitted between the first hub and the second hub of the synchronizing clutch and, in the second position, the output member rotates based on torque transmitted from the input member through the primary clutch.

2. The assembly of claim 1, wherein the primary clutch is a collar slidably positioned with respect to the input member.

3. The assembly of claim 1, wherein the input member comprises a sprocket.

4. The assembly of claim 1, wherein the input member is coupled to the first hub through a hollow shaft and wherein the output member is coupled to the second hub through an inner shaft coaxial with the hollow shaft.

5. The assembly of claim 1, wherein in the first position, the primary clutch is spaced apart from the input member and, in the second position, the primary clutch directly engages the input member.

6. The assembly of claim 1, wherein the synchronizing clutch is an electromagnetic clutch.

7. The assembly of claim 1, wherein along an axis of rotation of the output member, the input member is positioned between the synchronizing clutch and the output member.

8. The assembly of claim 1, further comprising an impeller rotationally coupled with the input member and configured to pump lubricant away from the input member.

9. A method, comprising:
- rotating an input member through connection with a drive shaft spaced apart from the input member;
- engaging a synchronizing clutch coupled to the input member to rotate an output member;
- moving a primary clutch from a first position to a second position during rotation of the input member and while the synchronizing clutch is engaged, wherein the output member rotates based on torque generated through the synchronizing clutch while the primary clutch is in the first position and wherein the output member rotates based on torque generated through the primary clutch while the primary clutch is in the second position.

10. The method of claim 9, wherein the primary clutch is a collar slidably positioned with respect to the input member.

11. The method of claim 9, wherein the input member comprises a sprocket.

12. The method of claim 9, wherein the input member is coupled to the first hub through a hollow shaft and wherein the output member is coupled to the second hub through an inner shaft coaxial with the hollow shaft.

13. The method of claim 9, wherein in the first position, the primary clutch is spaced apart from the input member and, in the second position, the primary clutch directly engages the input member.

14. The method of claim 9, wherein the synchronizing clutch is an electromagnetic clutch.

15. The method of claim 9, wherein along an axis of rotation of the output member, the input member is positioned between the synchronizing clutch and the output member.

16. The method of claim 9, further comprising disengaging the synchronizing clutch after the primary clutch has moved to the second position.

17. A vehicle, comprising:
- an engine;
- a primary drive shaft coupled to the engine and a transmission spaced apart from the engine;
- a power take-off assembly coupled to the primary drive shaft and positioned between the engine and the transmission, comprising:
- an input member, an output member, a synchronizing clutch and a primary clutch, the primary clutch operable in a first position, wherein rotation of the output member is based on engagement of the synchronizing clutch, and a second position, wherein torque is transmitted from the input member, through the primary clutch to the output member.

18. The vehicle of claim 17, wherein the primary clutch is a collar slidably positioned with respect to the input member.

19. The vehicle of claim 17, wherein the input member comprises a sprocket.

20. The vehicle of claim 17, wherein the input member is coupled to the first hub through a hollow shaft and wherein the output member is coupled to the second hub through an inner shaft coaxial with the hollow shaft.

21. The vehicle of claim 17, wherein in the first position, the primary clutch is spaced apart from the input member and, in the second position, the primary clutch directly engages the input member.

22. The vehicle of claim 17, wherein the synchronizing clutch is an electromagnetic clutch.

23. The vehicle of claim 17, wherein along an axis of rotation of the output member, the input member is positioned between the synchronizing clutch and the output member.

24. The vehicle of claim 17, further comprising a housing surrounding the power-take off assembly and an impeller rotationally coupled with the input member and configured to pump lubricant away from the input member to a position external the housing.

* * * * *